SPECIFICATION

To All Whom It May Concern:

Be It Known That We,

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BEARING ARRANGEMENT FOR A VEHICLE DIFFERENTIAL

CROSS REFERENCE TO RELATED APPLICATIONS

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not Applicable

BACKGROUND OF THE INVENTION

This invention relates in general to antifriction bearings and more particularly antifriction bearings for vehicle differentials.

The typical differential for an automotive vehicle has a housing in which meshed pinion and ring gears rotate, the former being connected to the transmission for the vehicle and the other being on a differential carrier having stub shafts which rotate in bearings set into the housing. The carrier has a cross shaft on which a pair of beveled gears rotate, and those bevel gears mesh with more bevel gears that are connected to the axle shafts which extend away from the carrier to driven road wheels. The bevel gears connected to the axle shafts have the capacity to rotate within the differential carrier at different angular velocities to compensate for the different angular velocities at which the two axle shafts will rotate when the vehicle negotiates a turn, for example.

Almost universally the two bearings which fit around the carrier shafts to support the carrier are single row tapered roller bearings which are mounted in opposition. As such, the bearings confine the carrier both radially and axially, but nevertheless allow the carrier to rotate in the differential housing with minimal friction. The two bearings are adjusted against one another to a setting which

provides a good measure of stability to the carrier -- indeed, one in which internal clearances are eliminated from the bearings. The location of the bearings along their common axis controls the mesh setting of the ring gear and the pinion, so the bearings are further adjusted to achieve the correct mesh setting.

In the typical differential the cones (inner races) of the two bearings fit around the two stub shafts on the carrier, while the cups (outer races) fit into the housing where they are backed by cup adjustors which thread into the housing (Fig. 2). By turning the two adjustors one can adjust the bearing setting and the mesh setting.

The cup adjustors represent additional components for the differential and add weight to it, as do locking devices which prevent the adjustors from rotating once they are turned to the positions which provide the proper settings. Moreover, the adjustors occupy space within the differential, and that is reflected in increased width and weight for the differential housing. While the adjustors confine the cups of the bearings axially, they do not prevent the cups from rotating in the housing, and such rotation can produce wear in the housing and on the cups as well.

SUMMARY OF THE INVENTION

The present invention resides in a bearing arrangement for a differential, which differential includes a housing that contains bearing seats and a carrier that is located within the housing. The carrier has stub shafts which project into the bearing seats. The bearing arrangement includes single row antifriction bearings which fit around the stub shafts and have outer races that are received

in the bearing seats. The outer races have external threads which engage internal threads in the bearing seats. The invention also resides in a threaded cup for a differential bearing combined with a ring attached to the cup so that a tool can engage the cup and rotate it.

BRIEF DESCRIPTION OF DRAWINGS

Fig. 1 is a sectional view of an automotive differential provided with a bearing arrangement constructed in accordance with and embodying the present invention;

Fig. 2 is a fragmentary sectional view of a conventional differential of the prior art at one of the bearings that supports the ring gear carrier of that differential and further showing a threaded adjustor and locking ring for securing the adjustor;

Fig. 3 is a sectional view at one of the bearings that form part of the bearing arrangement representing the present invention;

Fig. 4 is a fragmentary sectional view taken along line 4-4 of Fig. 1;

Fig. 5 is a fragmentary sectional view of the cup for one of the carrier bearings of the bearing arrangement;

Fig. 6 is a fragmentary sectional view of the seat for one of the carrier bearings;

Fig. 7 is a sectional view of the cup for one of the carrier bearings with a locking ring attached to the cup;

Fig. 8 is an end view of the locking ring and cup taken along line 8-8 of Fig. 7;

Fig. 9 is a perspective view of an adjustment tool capable of engaging a locking ring of either carrier bearing and rotating it and the cup to which it is attached;

Fig. 10 is a fragmentary sectional view of a alternate cup for a carrier bearing; and

Fig. 11 is a fragmentary sectional view of another alternate cup for a carrier bearing.

DETAILED DESCRIPTION OF INVENTION

Referring now to the drawings, a vehicle differential A (Fig. 1) delivers torque to two axle shafts B which extend out to road wheels to which they are coupled. The differential A enables the axle shafts B to rotate at different angular velocities while delivering torque to both of them, a condition encountered when negotiating turns.

In very basic terms, the differential A includes (Fig. 1) a housing 2, a pinion 4, a ring gear 6 driven by the pinion 4, and a carrier 8 to which the ring gear 6 is attached, so that the pinion 4 likewise drives the carrier 8. The differential A also includes a bearing arrangement C that supports the carrier 8 in the housing 2. The pinion 4 rotates about a longitudinal axis Y, whereas the ring gear 6 and carrier 8 rotate about a transverse axis X, this rotation being accommodated by the bearing arrangement C which includes two single row tapered roller bearings 10 and 12 mounted in opposition – indeed, in the direct configuration. As such the bearings 10 and 12 confine the carrier 8 and ring gear 6 axially along the transverse axis X, while leaving it free to rotate.

The pinion 4 lies at the end of a shaft 16 which rotates in bearings 18 mounted in the housing 2. The bearings 18, while permitting the shaft 16 and its pinion 4 to rotate about the axis Y, confine the pinion 4 radially and axially, so that the pinion 4 assumes fixed radial and axial positions along the axis Y.

Along the transverse axis X the housing 2 has two bearing seats 20 (Fig. 4) in the form of half bores 22 which open into the interior of the housing 2 and caps 24 which fit over the half bores 22 and are attached firmly to the housing 2 with cap screws 26. Each half bore 22 contains an internal thread 28 (Fig. 6), which is of uniform diameter and continues into the cap 24 which closes that half bore 22. In other words, the two bearing seats 20 are threaded. Each thread 28 has truncated crests, but its roots are V-shaped. The bearings 10 and 12 fit into the bearing seats 20.

Of course, the threads 28 of the two bearing seats 20 are cut before the bearings 10 and 12 are installed in those seats 20. To produce the thread 28 in either seat 20, the cap 24 for the seat 20 is secured in the housing 2 with the cap screws 26. Then a boring tool having a diameter corresponding to the diameter of the truncated crests on the thread 28 is run through the half bore 22 and cap 24 in which the seat 20 is to be formed. Next the thread 28 is cut.

The carrier 8 occupies the interior of the housing 2 where it is supported by the bearing arrangement C that includes the bearings 10 and 12 (Fig. 1). They enable the carrier 8 to rotate in the housing 2 about the axis X, yet confine it axially in the housing 2. To this end, the carrier 8 has stub shafts 32, also known as ring gear

shafts, which project from shoulders 34 into the bearing seats 20 and into the bearings 10 and 12 in those seats 20.

Between its two stub shafts 32, the carrier 8 has (Fig. 1) a cross shaft 36, the axis of which is perpendicular to the axis X. The cross shaft 36 carries bevel gears 38 which mesh with more bevel gears 40, with the latter having journals 42 that project into the carrier 8 where they are free to rotate about the axis X. The journals 42 are hollow and receive the axle shafts B, with the journals 42 and the shafts B being engaged at mating splines 44.

The ring gear 6 is attached to the carrier 8 with cap screws 46. It meshes with the pinion 4. When the pinion shaft 16 rotates, it drives the carrier 8 through the meshed pinion 4 and ring gear 6, and the carrier 8 revolves about the axis X. The cross shaft 36 rotates with the carrier 8 and through the meshed bevel gears 38 and 40 rotates the axles shafts B. Normally the two axle shafts B rotate at the same angular velocity, but the arrangement permits one to revolve at a different velocity than the other.

Each bearing 10 and 12 includes (Fig. 3) an outer race in the form of a cup 50, an inner race in the form of a cone 52 located within the cup 50, and rolling elements in the form of tapered rollers 54 arranged in a row between the cup 50 and cone 52. Each bearing 10 and 12 also includes a cage 56 in its row of tapered rollers 54 to maintain the correct spacing between the rollers 54. The axes of the two bearings 10 and 12 coincide with the axis X.

The cup 50 of each bearing 10 and 12 has a tapered raceway 60 which is presented inwardly toward the axis X and a back face 62 at the small end of the

raceway 60. The back face 62 lies perpendicular to the axis X and out of it open several axially directed holes 64. Along its outwardly presented surface, that is its OD, the cup 50 has a thread 66 and a smooth cylindrical surface 68 beyond the thread 66. The thread 66 occupies between 33 % and 50 % of the length of the cup 50 and extends from the back face 62 toward the opposite end of the cup 50. It thus encircles the cup 50 at the small end of the tapered raceway 60. The pitch and diameter of the thread 66 correspond to the pitch and diameter of the thread 28 in either of the seats 20 in the sense that the thread 66 will engage the thread 28, although with a slight clearance. Actually, the difference between the pitch diameters of the two threads 28 and 66 should range between 0.0030 and 0.0190 inches. The diameter of the cylindrical surface 68 exceeds the minor or least diameter for the external threads 68 on the cup 50 and is less than the diameter for the internal thread 28 on the bearing seat 20 at the truncated crests of the thread 28. The difference between the diameter of the cylindrical surface 68 and the diameter of the truncated crests for the thread 28 should range between 0.0005 and 0.0030 inches.

Preferably the cups 50 are formed from steel and are induction hardened along their raceways 60, but not elsewhere. Alternatively, the cups 50 could be formed from case carburized steel and the threads 66 hard turned.

The cone 52 for each bearing 10 and 12 lies within the cup 50 for that bearing and has a tapered raceway 72 which is presented outwardly away from the axis X and toward the cup raceway 60. The cone 52 at the large end of its raceway 72 has a thrust rib 74 and at the end of the thrust rib 74 a back face 76 which is perpendicular to the axis X.

The tapered rollers 54 for each bearing 10 and 12 lie in a single row between the raceways 60 and 72 of the cup 50 and cone 52, respectively, for that bearing. They contact the raceways 60 and 72 along their tapered side faces, while their large end faces bear against the thrust rib 74 of the cone 52. The rollers 54 are on apex, meaning that the conical envelopes in which their tapered side faces lie have their apices at a common point along the axis X. The apices for the conical envelopes for the raceways 60 and 72 lie at the same point.

The cone 52 for the bearing 10 fits over the left stub shaft 32 on the carrier 8 (Fig. 1), preferably with an interference fit. Its back face 76 bears against the shoulder 34 from which the stub shaft 32 projects. The cage 56 holds the rollers 54 around the raceways 72 of the cone 52, so that the cone 52 and rollers 54 are installed as a unit known as a cone assembly. The cup 50 for the bearing 10 threads into the left bearing seat 20, its external thread 66 engaging the internal thread 28 of the left seat 20. The cone 52 for the right bearing 12 is installed on the right stub shaft 32 and the cup 50 into the right bearing seat 20 in a like manner. The tapered rollers 54 for the bearing 10 taper downwardly away from the carrier 8 and so do the rollers 54 for the bearing 12. Thus, the tapered rollers 54 for the two bearings 10 and 12 taper in opposite directions such that the bearings 10 and 12 are mounted in the direct configuration.

The cones 52 and their rollers 54, that is, the cone assemblies, need to be installed over the stub shafts 32 before the caps 24 are fitted to the housing 2. Once the cones 52 are fitted to the stub shafts 32, the cups 50 are fitted around the rollers 54 that are located around the cones 52. In other words, the bearings 10 and 12 are

installed around the stub shafts 32. With the bearings 10 and 12 fitted to their stub shafts 32, the carrier 8 is lowered into the housing 2 such that the bearings 10 and 12 drop into the half bores 22. Either cup 50 may require a slight rotation clockwise or counterclockwise to insure that the thread 66 on it engages the thread 28 of the half bore 22 in which the cup 50 locates. A fixture may be used to hold the cups 50 in place, thus insuring that the bearings 10 and 12 remain with the carrier 8 as it is lowered into the housing 2.

Next the caps 24 are fitted to the housing 2 over the half bores 22 and the threads 28 in the caps 24 likewise engage the threads 66 of the cups 50. The caps 24 are secured with the cap screws 26 (Fig. 4). This completes the bearing seats 20, and they encircle the two bearings 10 and 12.

Thereupon, the bearings 10 and 12 are adjusted. To this end, the cups 50 are advanced and retracted in their bearing seats 20 by rotating them. They are positioned such that the bearings 10 and 12 possess a light preload, and such that the correct mesh exists between the pinion 4 and the ring gear 6. The spacing between the two cups 50 controls the setting for the bearings 10 and 12. The lateral positions of the two bearings 10 and 12 along the axis X in the housing 2 controls the mesh setting. The adjustments for both settings are effected by rotating the cups 50 in their respective bearing seats 20.

In this regard, the cup 50 of each bearing 10 and 12, before it installed over its cone 52 and rollers 54, is fitted with a locking ring 80 (Figs. 7 & 8), which may be formed as a sheet metal stamping. It may assume any of a variety of configurations. Moreover, it may be attached to the cup by a variety of methods, including, welding

adhesives, screws, pins, and the like, at a variety of locations, including the back face 62, the front face, or the cylindrical surface 68. In one configuration, the ring 80 has drive studs 82 projected axially from one of its faces, and these drive studs 82 align with the holes 64 that open out of the back face 62 of the cup 50 to which the ring 80 is attached. The drive studs 82 fit tightly into the holes 64, into which they are forced, and this secures the locking ring 80 to the cup 50. The locking ring 80 has notches 84 which are arranged at equal circumferential intervals and are exposed beyond the back face 62 of the cup 50, all to provide formations which may be engaged to run the cup 50. The locking ring 80 remains with the cup 50 and is configured to be engaged by an adjustment tool D.

The tool D (Fig. 9) takes the form of a disk having tabs 86 along its periphery and a drive socket 88 at its center. It is configured to fit over or into the locking ring 80 with its tabs 86 received in the notches 84, so that disk 90 and ring 80 are engaged and will rotate in unison. This rotation may be effected by a wrench that engages the tool at its drive socket 88. Indeed, the tool D is engaged with the ring 80 on each cup 50, and the cups 50 are rotated with the tool D to give the bearings 10 and 12 the proper setting and to establish the correct mesh setting for the pinion 4 and ring gear 6.

While serving to couple the tool D to the cups 50 so as to adjust the location of the bearings 10 and 12 along the axis X, the locking rings 80 serve the equally important function of securing the cups 52 against rotation once they are rotated to the correct positions in their respective bearing seats 20. To this end, the locking ring 80 for each cup 50, being formed from sheet metal, may be easily deformed into a

recess or other cavity in the bearing seat 20, thereby preventing its rotation and rotation of the cup 50 within the seat 20.

The fit between the cylindrical surface 68 of each cup 50 and the truncated crests of the thread 28 for the seat in which that cup 50 is contained is tighter than the fit between the thread 66 in the cup 50 and the thread 28 of the ring seat 20. More specifically, the clearance between the truncated crests of the internal thread 28 and the cylindrical surface 68 of the cup 50 is less than the difference between the pitch diameters of the internal thread 28 of the ring seat 20 and the external thread 66 on the cup 50, the former being larger than the latter. The arrangement is such that radial and tilting loads transfer from the carrier 8 to the housing 2 through the cylindrical surfaces 68 on the two cups 50. Axial or thrust loads, on the other hand, transfer between the carrier 8 and housing 2 through the engaged threads 28 and 66 on the two bearing seats 20 and cups 50. The difference in the fit between the pitch diameters and between the cylindrical surface 68 and the crest of the threads 28 should range between 0 and 0.0185 inches.

The cups 50 for the two bearings 10 and 12 have a one-piece construction in which the threads 66 for each cup 50 are an integral part of the cup 50. An alternate cup 90 (Fig. 10) consists of two elements – a major element 92, on which the raceway 60, back face 62, and cylindrical surface 68 exist, and a ring 94 on which the thread 66 exists. Beyond the cylindrical surface 68, the alternate cup 90 has an annular relief 96 in the form of a rabbet. The ring 94 fits in the relief 96 with its thread 66 projecting beyond the cylindrical surface 68 on the major element 92. The locking

ring 80 is attached to the ring 94. The ring 94 may be secured to the major element 92 with an interference fit or by a weld or both.

An alternate locking ring 100 (Fig. 11) may be fitted to the alternate cup 90. To this end, the alternate locking ring 100 has an axially directed wall 102 which fits into the relief 96 and is encircled by the threaded ring 94, so that the wall 102 is captured between the ring 94 and the major component 92. Interference fits exist so that the component 92, threaded ring 94, and locking ring 100 are all held firmly together.

Other variations are available as well. For example, the internal thread 28 of each bearing seat 20 need not extend the full length of the seat 20, but instead may lead up to a smooth cylindrical surface. That surface would lie opposite cylindrical surface 68 of the cup 50 or 90 that locates with the seat 20. The threads 28 and 66 in the bearing seats 20 and on the cups 50, respectively, are actually helices, and other forms of helices may be used, such as ball screws. Also, other bearings with inclined raceways – for example, angular contact ball bearing – may be substituted for the tapered roller bearings 10 and 12. In that event, the outer races of the substituted bearings would have threads 66 and cylindrical surfaces 68.

The seats 20 with their threads 28 and the cups 50 with their mating threads 66, enable the differential A to occupy less width than its counterparts provided with conventional cup adjustors. Also, the differential A requires fewer parts and is easier to assemble. Less weight accompanies the lesser width and reduced part count. In addition, the cups 50 do not rotate in the housing 2, and this prevents wear in the

bearing seats 20 and on the cups 50, thus extending the life of the differential A beyond its conventional counterparts.